Lesson 1:
Geology Training Module

Students review the basic requirements for human survival. Using an online, multimedia module, they make changes to Earth's layers and draw conclusions about the geologic conditions that are necessary for human survival.

Main Concept: Certain geologic conditions help to support human survival.

Scientific Question: What geologic conditions are required for human survival?

Objectives	Standards
• Students make changes to Earth's interior and write descriptive, objective observations of the effects of these changes on Earth. • Students will identify the characteristics of Earth's structure that are required to allow for human survival.	**Meets:** NSES: A (5-8) #1 ISTE: 3, 5 **Partially meets:** NSES D (5-8) #1.1 NSES D (5-8) #1.2 **Addresses:** 2061: 4B (6-8) #2 2061: 4C (9-12) #4 NSES: B (5-8) #3.2

Assessment	Abstract of Lesson
Write-up in Astro Journal.	Students review the basic requirements for human survival and predict how human survival requirements are met by characteristics of the Earth's structure. They engage in an online Geology Training module in which they make changes to the Earth's interior and observe the effects of these changes on Earth. They then draw conclusions about which geologic conditions are necessary to support human survival.

Prerequisite Concepts	Major Concepts

• Humans need water, oxygen, food, gravity, a moderate temperature, and protection from poisonous gases and high levels of radiation to survive. (Astronomy Lesson 1)
 	
• Humans need a yellow star, a planet with a mass of 1/4 to four times Earth's mass orbiting in the Habitable Zone, and a Jupiter-size planet in a nearly circular orbit beyond 3AU. (Astronomy Lesson 2)
 	
• Humans need the following atmospheric conditions (Atmosphere Lesson 1):
  • 0.000001 to 20% water vapor
  • 0.001 to 0.03% carbon dioxide
  • More than 80 Dobson Units of ozone in the stratosphere
  • 15 to 30% oxygen
  • More than 5% nitrogen
 	
• Systems consist of many parts that usually influence each other. Something may not work as well (or at all) if a part of the system is missing, broken, worn out, mismatched or misconnected. (Astronomy Lesson 7)
 	
• Scientific observations are detailed descriptions of what can be learned using the senses and scientific instruments. These scientific observations do not include ideas, opinions, or speculations about what is being observed.
 	
• A cause is something that produces an effect or result.
 	
Note to Teacher: Earth's interior conditions, density, convection, plate tectonics, volcanism, and carbon cycle are all explored and defined in later lessons. In this lesson, students simply need to make good observations about "what" is needed for human survival. Lessons 2 through 7 will give them the "whys" behind these needs.
	• The following geologic characteristics allow Earth to remain habitable to humans:
	  • Liquid outer core (coupled with the planet's rotation and a thick atmosphere)
	  • Viscous mantle (slow motion)
	  • Slow motion of crust and upper mantle (lithosphere) of 3-5 cm/year

Suggested Timeline (45-minute periods):
Day 1: Engage and Explore Part 1 Sections
Day 2: Explore Part 2 Section
Day 3: Explain, Extend/Apply, and Evaluate Sections

Materials and Equipment:

- Human Survival Transparency
- 1 Geologist Career Fact Sheet for each group
- Geologic Conditions Transparency
- A class set of Astro Journal Lesson 1: Geology Training Module
- 1 Planetary Geology Comparison Chart for each group
- 1 copy Geology Training Walkthrough (optional)
- Geology Training Screen Shots transparencies (optional)
- 1 to 30 computers with Internet browser, Internet connection, and the Flash 6 Player installed*
- A printer connected to the computers
- Chart paper
- Overhead projector
- LCD projector or TV connected to a computer with video card (optional)

Preparation:

- Prepare class sets of Astro Journals.
- Prepare overhead transparencies.
- Make copies of Astro Journal, Planetary Geology Comparison Chart, and Geologist Career Fact Sheet.
- Download and install Flash 6 Players on computers. Test these at http://astroventure.arc.nasa.gov by clicking "Geology Training."
- Prepare chart paper with major concept of the lesson and human survival needs to post at the end of the lesson.

*System Requirements to Run Geology Training Module

Operating System	Browser
Windows 95 Windows 98 Windows Me	Internet Explorer 4.0 or later (Internet Explorer 5.0 or later is recommended), Netscape Navigator 4 or later, Netscape 7.0 or later (Netscape 6 is not recommended)
Windows NT Windows 2000 Windows XP or later	Internet Explorer 4.0 or later, Netscape Navigator 4 or later, Netscape 7.0 or later, with standard install defaults (Netscape 6 is not recommended)
Macintosh: System 8.6 System 9.0 System 9.1 System 9.2	Netscape 4.5 or later (Netscape Communicator 4.7 or Netscape 7.0 are recommended), Netscape 7.0 or later, (Netscape 6 is not recommended) Microsoft Internet Explorer 5.0 or later
Macintosh OS X 10.1 or later	Netscape 7.0 or later (Netscape 6 is not recommended), Microsoft Internet Explorer 5.1 or later

RAM

The minimum requirement for RAM is 32 MB; however, the animations will run slowly and it will be slow sending the Astro Journal and Certificate to the printer at the end of the module. We recommend a minimum of 64 MB.

Sound

Astro-Venture uses narration and some sound effects. Computers will require a sound card and either headphones or speakers. Pairs of students using the same computer can use a y-cable to connect two pairs of headphones to one computer.

Differentiation:

Accommodations
For students who may have special needs:
- Pair advanced students with students that may need more guidance. Encourage students to talk about what they are learning.

Advanced Extensions
For students who have mastered this concept:
- Research and report on whether the composition of Earth's interior is important to human survival and why or why not.

Engage (approximately 10 minutes)

1. **Review human survival needs (Astronomy Lesson 1), astronomical conditions that support human survival (Astronomy Lesson 2), atmospheric conditions that support human survival (Atmosphere Lesson 1), and systems (Astronomy Lesson 7).**

   - Question: As members of the Astro-Venture Academy, what is our goal?
   - *Answer: Our goal is to find, study, and design planets that would be habitable to humans.*

   - Question: In the first lesson of Astronomy, what elements did you learn are necessary for human survival?
   - *Answer: The elements that humans need for survival are: food, gravity, oxygen, water, a moderate temperature, and protection from poisonous gases and high levels of radiation.*

   - Put up the Human Survival Transparency.

   - Question: In Astronomy, which of these necessary elements did we learn are influenced by astronomical conditions in our star system and planet?
   - *Answer: We learned that star type, orbital distance, and planetary mass all determine the surface temperature of our planet, which in turn determine whether the planet can have liquid water. We learned that planetary mass determines the amount of gravity on a planet. We also learned that the orbit of any large objects, such as Jupiter, could disrupt this system.*

   - Write these factors on the transparency for "Moderate temperature" under "What Factors Provide This" as seen in the diagram below.

     Note to Teacher: You may have already filled out this chart in Atmosphere Lesson 1, in which case you can just review what was already written.

   - Question: In Atmosphere, which of these necessary elements did we learn are influenced by atmospheric conditions in our star system and planet?
   - *Answer: We learned that greenhouse gases such as water vapor and carbon dioxide absorb and reradiate heat, playing a role in Earth's surface temperature. We learned that nitrogen is an important building block for proteins and, as an inert gas, greatly contributes to necessary air pressure. We also learned that oxygen is highly reactive, allowing us to get energy from sugars and that ozone absorbs harmful radiation preventing much from reaching Earth's surface.*

- Write these factors on the transparency for "Moderate temperature" and "Protection from high levels of radiation" under "What Factors Provide This" as seen in the diagram below. (Astronomy factors are in plain text and Atmosphere factors are *italicized*.)

Humans need:	**Reason:**	**What Factors Provide This:**
Food	Gives us energy so that we can move, grow, and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh, and organs.	*Nitrogen is a nutrient*
Oxygen	Helps us to obtain energy from sugars.	*Oxygen helps us get energy from sugars*
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.	(related to temperature) *Water vapor is a greenhouse gas in our atmosphere*
Moderate temperature (Average global temperature below 50º C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/objects could disrupt) *Greenhouse gases reradiate heat*
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease, and damage to the body.	*Ozone protects from UV* *Our atmosphere doesn't have high levels of poisonous gases*
Gravity	Allows our biological systems to develop and function normally.	Planetary mass *Nitrogen provides pressure*

- Question: So far, we've looked at many of the factors necessary for human survival. If a planet has all of these astronomical and atmospheric conditions, is it habitable to humans? Explain.
- *Answer: It is not necessarily habitable to humans, because it may not have other conditions necessary for human habitation. The Earth is a system and requires many different factors to work together for the system to work.*

- Question: What could happen if a part of the system were missing or broken?
- *Answer: The system may not work as well (or at all).*

- Question: Question: What other needed elements still need to be understood in order to make sure a planet is habitable to humans?
- *Answer: We need to understand what factors will allow our planet to have a moderate surface temperature and protection from harmful space radiation.*

2. Introduce the purpose of this lesson/unit.

- Question: What human survival needs did both astronomy and atmosphere play a role in?
- *Answer: Gravity and planetary surface temperature.*

- Question: What role does astronomy play in surface temperature?
- *Answer: Star type, orbital distance, and the mass of a planet all affect planet surface temperature.*

- Question: What role does our atmosphere play in surface temperature?
- *Answer: Greenhouse gases in the atmosphere absorb and reradiate heat.*

- Question: Why is planetary surface temperature such an important factor in human survival?
- *Answer: We can only survive in a pretty narrow temperature range, and we need liquid water to survive, which also relies on a very narrow temperature range.*

- Say: It turns out that Earth's geologic conditions also play an important role in the surface temperature. We will now begin to explore Earth's geology and how it supports our survival needs so that we can determine what conditions to look for on other planets and what to include in the design of a habitable planet.

3. Draw on students' prior knowledge of Earth's geology.

- Question: What do you know already about the inside of the Earth?
- *Answer: (Allow students to discuss their ideas about this. They may know that there is hot lava inside the Earth that causes volcanoes and movement that causes earthquakes.)*

Note to Teacher: You may want to make a drawing of what students think the inside of the Earth looks like and what the interior conditions are like.

4. Present the Scientific Question for this lesson.

- What geologic conditions allow for human survival?
- Tell students that they will be role-playing scientists and using a computer activity to find out what geologic conditions humans need to survive and why.

Explore

Part 1 - (approximately 35 minutes)

1. Put up the Geologic Conditions Transparency and help students identify possible geologic conditions for human survival.

- Say: In the Geology section of Astro-Venture, we will be focusing on Earth's interior, and we will examine how Earth's interior helps to support the conditions we need to survive. We will call these conditions the geologic conditions.

- Question: What do you think are some of the characteristics of Earth's interior that allow Earth to be habitable to humans?
- *Answer: (Accept all answers. Record these ideas on Geologic Conditions Transparency under Predicted Geologic Condition.)*

- In the Prediction section of their Astro Journal, have students record their predictions of the geologic conditions that they think are necessary for human habitation on a planet.

2. Introduce Geology careers.

- Tell students that as they go through the Geology Training module, they will be role-playing geologists.
- Ask students what kinds of things they think a geologist might do and what kind of knowledge they might need to have.
- Pass out the Geologist Career Fact Sheet for students to read and discuss this career.

3. Introduce students to the Astro-Venture Geology Training module.

- Tell students that they will be engaging in an online activity where they will change aspects of the geologic conditions of our planet and will observe the effects on Earth. They will then draw conclusions about the geologic conditions needed for human survival.

- Tell students that as they go through this module, they will be Astro-Venture Junior Geologists, and will be evaluated on how detailed their observations are and whether they give reasons for the effects they observe. They will be able to use their notes on the Astro Challenge, so they should take thorough notes.

- You may want to model for students an example of a "good observation." Either project from a computer for the class to see or project the Geology Training Screen Shots with an overhead projector to walk the students through the following. (You will need to click through the introduction to get to this part.)

- Question: Based on your observations of the introductory animations and buttons, how is the inside of the Earth structured?
- *Answers may include: The Earth has a crust, mantle, and core. These sections are further divided into the lithosphere, asthenosphere, lower mantle, inner core, and outer core.*

- Encourage students to explore the Astro Facts and make observations about the characteristics of these sections of the Earth and why the Earth might be divided up this way. Tell them that you will be discussing the structure later.

  Note to Teacher: Although it may be tempting to want to define all of the layers of the Earth for students up front, research shows that students will develop a better understanding if they first explore the concepts, form their own ideas and then discuss the scientific explanations. This method also encourages students to learn to look for information when they have questions, which is an essential skill for successfully navigating the Internet and the growing volume of information that is available.

- Click "Outer Core."
- Click "liquid."
- Click "Play" to see the effect on Earth.
- Ask students to describe what happened to Earth and why. Record a good example of the kinds of observations you expect from students such as: "The solar wind heads toward Earth, but does not reach Earth's surface, which allows everything to survive."

  Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

- Click "Enter" to see other scientists' observations. Stress to students that they do not need to type the exact same thing, but should have the same general idea.

  Note to Teacher: Students can change their answer after they click "Enter." Both their original answers and their new answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

- Point out to students that when they have completed an observation, the button for that characteristic turns purple. They must complete all observations in all three major sections before they can advance to the Astro Challenge section.

Note to Teacher: Some students may wonder why they can't just find the characteristics that allowed Earth to remain habitable and go on. Making good observations about the effects of life-threatening changes in the Earth's structure will help students understand why each characteristic of Earth's structure is important to life.

- Click "Astro Facts" to read helpful background information about each main topic. This information can help students understand some of the effects they are observing and the overall importance of each characteristic to human life.
- Within the "Astro Facts," glossary words are in white. Click a white word and the definition will come up in a box. Click the "X" to close this box.
- Click the back arrows to return to the animations.
- Click "solid."
- Click "Play."

Note to Teacher: The effect for solid outer core is different than the other buttons and animations in this module of Astro-Venture. The necessity of a magnetic field for protection from solar wind and other forms of space radiation is a topic of active debate among scientists. The magnetic field does deflect space radiation, but some scientists think the mass of Earth's atmosphere alone could be enough to protect life for billions of years. This is an excellent opportunity to open up a discussion about the nature of science and that there isn't always a "right" answer. Explain that there are many questions that need to be answered and this is why a career in science is so exciting.

- Ask students to give a detailed observation such as: "We need protection from space radiation because it could kill most life on Earth."

Explore

Part 2 - (approximately 45 minutes)

1. **Have students engage in the Geology Training Module individually, in pairs, small groups, or as a class.**
   - Students should visit: http://astroventure.arc.nasa.gov and click "Geology Training."

Note to Teacher: You will need the Flash 6 Player plug-in, which can be downloaded and installed from http://www.macromedia.com/downloads. When tested with grades 5 to 8, the average completion time was 30 minutes with a range of completion times between 22 to 32 minutes. Also, you will want to have accessibility to a printer, so students can print their Astro Journals at the end of the module. These can be used for evaluation purposes. Students will also receive a certificate of achievement for completing the module. Make sure students are clear about the printing rules for both the Astro Journal and the certificate. After the Astro Challenge, they will have the option to print these items. This will be the only opportunity to print; students cannot go back later to print. If you want to take the whole class through the module using one computer, use the Geology Training Walkthrough at the end of this lesson as a guide.

Explain (approximately 15 minutes)

1. **Have students fill out the Results and Conclusion section of their Astro Journals.**

2. **Discuss students' conclusions and record them on the Geologic Conditions Transparency.**
   - Question: What differences did you notice between the crust, mantle, and core?
   - *Answer: The crust is a solid, relatively thin layer of rock on the Earth's surface. The mantle is a large region of slow-moving rock that lies between the crust and the core. The core is a dense area in the center of the Earth.*

   - Question: How are these three main sections further divided?
   - *Answer: The crust and mantle are further divided into the lithosphere, asthenosphere, and lower mantle. The lithosphere is composed of the crust and uppermost part of the mantle, which move together as plates on top of the Earth's surface by riding on top of the asthenosphere. The asthenosphere is part of upper mantle below the lithosphere and is partially molten. Below the asthenosphere is lower mantle. The core is also divided into two sections: the outer core, which is composed of liquid metal, and the inner core that is solid metal.*

   - Say: You can think of the crust, mantle, and core as compositional sections of the Earth, while the sub-sections define how the Earth moves.

   - Question: What geological conditions did you observe are necessary for human habitation of a planet?
   - *Answer: (Record on the board) We need a liquid outer core (and thick atmosphere), a viscous, slow-moving mantle, and slow motion (3-5 cm/year) of the crust and upper mantle (lithosphere).*

   - Question: Why do we need each of these? What happens to the planet otherwise?
   - *Answer: (Record the reasons next to each factor)*

Observed Geologic Condition	Reason
Liquid outer core	To produce a magnetic field that, along with the atmosphere, protects Earth from solar wind and space radiation
Viscous mantle (slow motion)	Provides enough volcanic activity to produce the right amount of carbon dioxide in the atmosphere to maintain a moderate temperature
Slow motion of lithosphere (crust and upper mantle at 3-5 cm/year)	Continues the recycling of carbon dioxide in our atmosphere to maintain a moderate temperature

Note to Teacher: Students may ask how we know what the interior of the Earth is like, since we cannot dig down that far. (Some students may have read about this in the Astro Facts section of the module.) You may want to point out that the deepest research hole was only 12 km deep (about 7.5 miles), which is not very deep considering the average thickness of the crust is 40 km (almost 25 miles). The mantle extends down to 2900 km (1800 miles) and the center of the Earth's core is over 6300 km deep (almost 4,000 miles). Scientists use seismometers to study how seismic waves travel through the Earth to learn about the Earth's mantle and core.

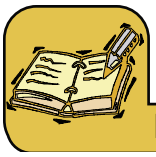
- Question: Of all of our human survival needs, for which ones does geology have an important role?
- *Answer: Geology plays a role in maintaining a moderate temperature and protecting us from harmful radiation.*

- Put up the Human Survival Transparency again and add this new information to it as follows: (Bolded text denotes geologic factors.)

Humans need:	**Reason:**	**What Factors Provide This:**
Food	Gives us energy so that we can move, grow, and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh, and organs.	*Nitrogen is a nutrient*
Oxygen	Helps us to obtain energy from sugars.	*Oxygen helps us get energy from sugars*
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.	(related to temperature) *Water vapor is a greenhouse gas in our atmosphere*
Moderate temperature (Average global temperature below 50º C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	Star type Orbital distance Planetary mass (Orbits of large planets/objects could disrupt) *Greenhouse gases reradiate heat* **Crust and mantle motion cycle carbon in and out of atmosphere**
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease, and damage to the body.	*Ozone protects from UV* *Our atmosphere doesn't have high levels of poisonous gases* **Liquid outer core forms magnetic field that helps to protect from solar wind and space radiation**
Gravity	Allows our biological systems to develop and function normally.	Planetary mass *Nitrogen provides pressure*

Extend/Apply (approximately 15 minutes)

1. **Have students apply these geologic conditions to another planet in our solar system.**
   - Have students choose another planet in our solar system, and use the Planetary Geology Comparison Chart to describe what geologic conditions would need to change in order for the selected planet to be habitable. They should record this information in the Creating Habitable Conditions for Other Planets section of their Astro Journals.



Evaluate (approximately 15 minutes)

1. **As a class, have students share their planet and discuss what geologic changes would be necessary to make it habitable to humans.**
   Based on what students know so far, their assessments should include the following observations:
   - All planets, with the exception of Earth and Venus, lack active mantle and crust motion.
   - Venus has volcanoes that appear to be young and also has possible evidence of recent plate motion.
   - With the exception of Earth, the inner planets do not have a global magnetic field, while most of the outer planets do.

2. **Have students complete their Astro Journals.**

3. **Collect students' Astro Journals and evaluate them to ensure that they have each mastered the major concepts:**
   - The following geologic characteristics allow Earth to remain habitable to humans:
     - Liquid outer core (coupled with the planet's rotation and a thick atmosphere)
     - Viscous mantle (slow motion)
     - Slow motion of crust and upper mantle (lithosphere) of 3-5 cm/year

4. **Bridge to next lesson.**
   - Question: What do you think the connection is between crust and mantle motion and the Earth's surface temperature?
   - *Answer: (Allow students to discuss their ideas about this.)*

   - Say: In the next lesson, we will begin to look at what drives the movement inside the Earth and how this motion affects surface temperature and our ability to survive on Earth.

   Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Astro Journal Lesson 1: Geology Training Module

Class/Period:

Name:

Date:

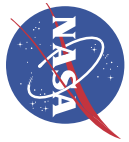
Scientific Question:

What geologic conditions allow for human survival?

1. Prediction: What geologic conditions do you think humans need to survive? Why?

2. Data: The following may be recorded and printed online. However, if you are unable to print from the computer, you may use the following chart to record your observations.

Cause	Effect on Earth
Liquid outer core	
Solid outer core	
No mantle motion	
Slow mantle motion	
Fast mantle motion	
No crust motion	
Slow crust motion	
Fast crust motion	



Astro Journal Lesson 1: Geology Training Module

Name:

Class/Period:

Date:

3. Results: What geologic conditions allow for human survival? Why? (Create a revised list below based on what you learned from the Geology Training module.)

4. Conclusions: Compare and contrast your prediction and results. How did conducting research change your original ideas?

Astro Journal Lesson 1: Geology Training Module

Name:

Class/Period:

Date:

Creating Habitable Conditions for Other Planets:
Choose another planet in our solar system. Write a paragraph explaining what geologic conditions would need to change in order for this planet to be habitable and why.

Geology Training Walkthrough

The following is an explanation of each section of Geology Training. It offers suggestions for how you might take a whole class through the module if you only have one computer with the ability to project.

Introduction

1. Go through the introduction with students. This introduces Geology careers and explains the activity students will be going through to make changes to different features of the Earth's interior, to observe the effects, and to see how these features work together to make a planet habitable to humans.

2. Enter a name for the class, and click "Enter."

3. When you first enter the main activity, there is a movie that shows the layers of Earth. All buttons are inactive during this short movie.

Activity

1. Astro Ferret directs you through the steps the first time. After that you are on your own, but can click Astro for a reminder.

2. Click "Outer Core."

3. Click "liquid."

4. Click "Play" to see the effect on Earth.

   Note to Teacher: "Replay" can be clicked multiple times to see the effect again.

5. Ask students to describe what happened to Earth and why.

6. Have students record their observations in their copy of the Astro Journal under Data.

7. Call on individuals to share what they wrote and have them type their observations in the Astro Journal on the computer. Ask students if they think a "liquid outer core" allows Earth to be habitable or not and why or why not.

8. Record a good example of the kinds of observations you expect from students such as: "The solar wind heads toward Earth, but does not reach Earth's surface, which allows everything to survive.

   Note to Teacher: The sequence of events in this module is important. You may want to model this for students.

9. Explain that a good scientific observation is detailed and describes what is observed.

10. Tell students that since they will be able to use their notes when they take the Astro Challenge, they should take thorough notes.

11. Click "Enter" to see other scientists' observations. Stress to students that they don't need to type the exact same thing, but should have the same general idea.

    Note to Teacher: Students can change their answer after they click "Enter." Both answers will be printed in their Astro Journal so that you can see if they are making good, initial observations.

12. Point out to students that when they have completed an observation, that sub-menu button turns purple. They must complete all observations in all three major sections before they can advance to the Astro Challenge section.

13. Click "solid."

14. Click "Play."

15. Engage students in a discussion about the possible effects of a solid outer core. Students may observe that scientists do not agree on whether the loss of a magnetic field would endanger life because the atmosphere may offer enough protection.

    Note to Teacher: The effect for solid outer core is different than the other buttons and animations in this module of Astro-Venture. The necessity of a magnetic field for protection from solar wind and other forms of space radiation is a topic of active debate among scientists. The magnetic field does deflect space radiation, but some scientists think the mass of Earth's atmosphere alone could be enough to protect life for billions of years. This is an excellent opportunity to open up a discussion about the nature of science and that there isn't always a "right" answer. Explain that there are many questions that need to be answered and this is why a career in science is so exciting.

Completion of Activity

1. Continue through each level of "Outer Core," "Mantle Motion," and "Crust Motion."

2. Have the class record their observations in their Astro Journals and then have individuals take turns typing in their observations into the computer.

3. In the Data section of their Astro Journals, have students record the results of the changes they observed that resulted in a habitable Earth.

4. After all observations have been completed, click "Astro Challenge" on Astro Ferret and take the Astro Challenge as a class.

5. Encourage students to go back to the relevant sections and look at their notes in their Astro Journal to help answer the questions.

6. Have students vote on the answers.

Conclusion

1. Have students vote on the results that they found. Discuss how their results compare to their predictions.

2. Print the class certificate and the class Astro Journal, if you wish.

Geologist

Related Job Titles:

Geologist, Geological Scientist, Geoscientist, Earth Scientist

Job Description:

Geologists, geophysicists, and geochemists explore the Earth's evolution, its structures, the way it works, and the way its resources are used. They also examine interactions with chemical (air, water) and biological (plant and animal) factors. Geologists find mineral, water, and oil resources and help companies use them. Their work improves understanding of hazards like earthquakes and avalanches. They help explain the Ice Age and discover the truth about dinosaurs. They also play an important role in managing and conserving the environment.

Interests / Abilities:

- Do you enjoy the open air and four wheel drive travel?
- Would you like to visit countries around the world?
- Do you like camping?
- Are you interested in volcanoes?
- Do find it fun to play with maps and various devices?
- Would you like to hit rocks so hard they break?
- Would you like meet people from all over the world?
- Do you enjoy solving mysteries?
- Do you think fossils are cool?
- Do you like to collect rocks?

Education / Training Needed:

Geologists, begin their careers with a bachelor's degree in geology, geochemistry, geophysics or a related science. A strong background in math, science and geography is necessary. You may need a master's or Ph.D. for advanced geology. Project managers and consultants may also be expected to have further education, and possibly, business administration courses. Part-time field work may be available after the first year of college. The experience in the field is invaluable to your studies and to your later career.

Additional Resources:

- Astrobiology at NASA
  http://astrobiology.arc.nasa.gov
- The Astrobiology Web
  http://www.astrobiology.com
- NASA Specialized Center of Research and Training (NSCORT)/Exobiology
  http://exobio.ucsd.edu
- American Geological Institute
  http://www.agiweb.org/
- U.S. Geological Survey
  http://www.usgs.gov
- National Science Foundation
  http://www.nsf.gov
- Student Educational Employment Programs
  http://nasajobs.nasa.gov/stud_opps/employment/index.htm

Suggested School Subjects / Courses:

- Science (biology, chemistry, physics, astronomy, planetary science with laboratory research and fieldwork)
- Math
- Geography

Another course that can help greatly is English, for the many reports, meetings and presentations. As in other sciences, a second language is very valuable because geologists do a great deal of traveling. Computer skills are definitely a bonus.

Areas of expertise:

- *Hydrogeology* is the study of the movement, quality and quantity of water in soils and rocks.
- *Environmental Geology* involves studying the interaction between ground, water, atmosphere, biology and the activities of humankind.
- *Soil Sciences* are closely connected with geology since soils represent the uppermost covering layer.
- *Petroleum Geology* studies rock layers and ways to locate oil.
- *Economic Geology* involves the study of mineral deposits, exploration for new resources, and environmentally-safe disposal of mining waste.

What can I do right now?

- Join a local environmental club or organization.
- Take summer jobs or internships at parks, laboratories, museums or camps.
- Visit Astro-Venture regularly to participate in chats and activities.
  http://astroventure.arc.nasa.gov
- Call the American Association of Science and Technology Centers for information on science museums in your area that you might visit.
  (202) 783-7200
- Participate in science fair projects.

Geodynamics Scientist

Michael Purucker

Chief Scientist, Geodynamics

Geophysics and Space Geodesy
Contractor, Raytheon
NASA Goddard Space Flight Center

My job is to chart and understand the multitude of magnetic fields encountered in near-Earth and near-Mars space. Processes as diverse as fluid motion in the Sun and Earth, to the flow of heat out of the Earth's interior cause magnetic fields. By studying these magnetic fields we can learn about these processes and how strong they are. On a typical day, I will check and confirm results coming from three Earth-orbiting satellites with which I am involved. I'm also working with European colleagues on the development of a new Earth-orbiting mission that will use multiple satellites that are close together to map the time and space changes of the magnetic field. A typical day will also find me working with students, developing mathematical and computer-based models of the Martian or Earth magnetic fields that can be compared to observations.

How I first became interested in this profession:

I took a course in Earth Sciences during my freshman year in college from Gene Shoemaker. He was a fabulous teacher, and I began to work with him on research projects in geology and geophysics at his Caltech lab and in the US Geological Survey's lab in Flagstaff, Arizona.

What helped prepare me for this job:

My academic training, and many years of on-the-job training with other NASA, US, and international scientists.

My role models or inspirations:

Several teachers at Caltech, including Gene Shoemaker, Heinz Lowenstam, and Bruce Murray. All of them came from very practical backgrounds, in mineral or petroleum exploration, and all found underlying themes which motivated their later work and students.

My education and training:

- B.S. in Geophysics, California Institute of Technology
- M.S. in Planetary Science, California Institute of Technology
- Ph.D. in Geology, Princeton University

My career path:

- Seven years as a geophysicist with the U.S. Geological Survey
- Two years as an exploration geophysicist with Phoenix Corporation
- 17 years as a physicist at NASA

What I like about my job:

I like that my job challenges me every day and that I can travel to and interact with colleagues in France, Denmark, and Germany.

What I don't like about my job:

Any large bureaucracy like NASA requires constant attention, much of which is of little importance to what I want to do.

My advice to anyone interested in this occupation:

Get the best grounding in physics, math, and Earth science that you can.

Areas of expertise:

- Planetary Magnetic Fields

Oceanography Expert

Anna Hilting

Graduate Student

The calcium carbonate tests or shells of tiny organisms record the carbon and oxygen isotope chemistry of the ocean they live in. I study these records to learn how the chemistry of the ocean changed between 35 and 65 million years ago. because the ocean and atmosphere "talk" to each other, the tiny tests tell us about changes in climate through time.

People that are good at this job are like cameras with big lenses. They can zoom in to look at details and zoom out to see how the details fit in the larger picture.

In Astrobiology, we study what makes a planet habitable. Earth's carbon cycle helps maintain a climate that supports liquid water and life. I study the chemistry of carbon fossils buried in the deep sea cores to learn how changes in the carbon cycle may have affected Earth's climate over millions of years.

Areas of expertise:

- Oceanography and Climate Change

How I first became interested in this profession:

I consider myself a late bloomer. When I was young, I only understood that I wanted adventure more than a career. I did not know that careers could be adventurous! After years of adventure that included living on a sailboat and crossing the Atlantic on a boat, I knew I wanted to study the Earth, especially the ocean. When I got the chance, I went back to school and got a degree in geology. I was very motivated. I never knew science was so much fun!

What helped prepare me for this job:

After I graduated from college, I worked for a biolological oceanographer who does very exciting work. He goes on deep sea expeditions to study how tiny plants in the ocean help remove carbon from the atmosphere and bury it in the ocean. We thought a lot about how these plants help regulate our climate. We knew that the Earth had been much colder and much warmer in the past. I wanted to learn more about how the carbon cycle affects climate over Earth's history and what changes we can expect in the near future.

My role models or inspirations:

My wonderful professors at East Carolina University and Penn State University and my boss inspired me. Teachers appreciate people that really want to learn and they go out of their way to nurture you along your way.

My education and training:

- B.S., Geology, East Carolina University

My career path:

- Data Technician/Research Assistant for a Biological Oceanographer at Duke University Marine Lab for four years
- Graduate Student at Pennsylvania State University for two years

What I like about my job:

I've always liked stories. Earth Science is is all about the best stories. When I am researching, I am anticipating the story I'll get to tell.

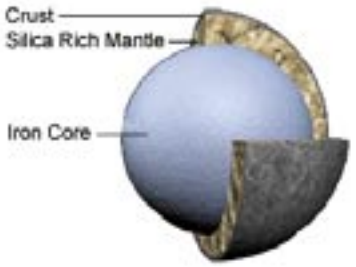
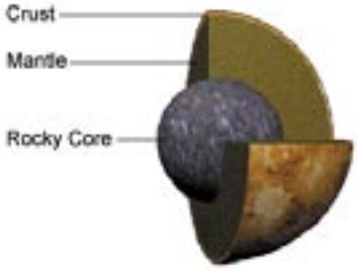
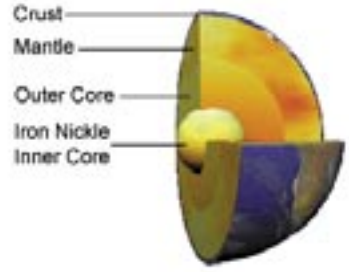
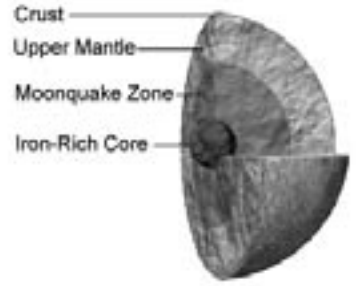
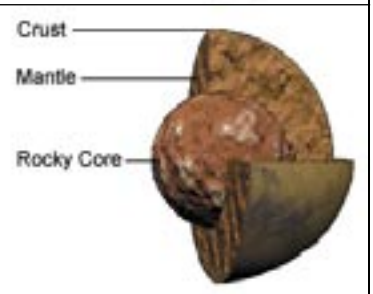
What I don't like about my job:

Sometimes there are too many little details that need attention and I forget to zoom out.

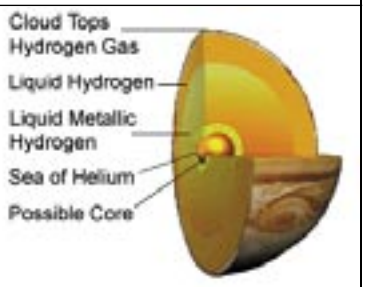
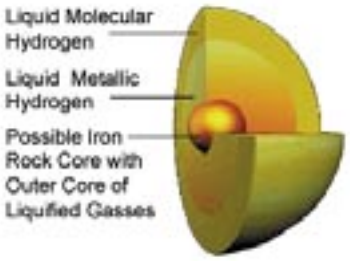
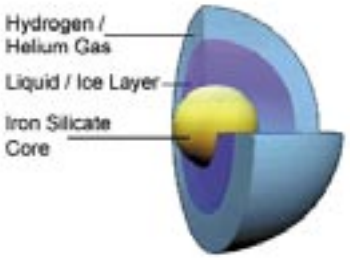
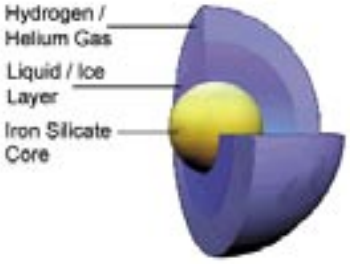
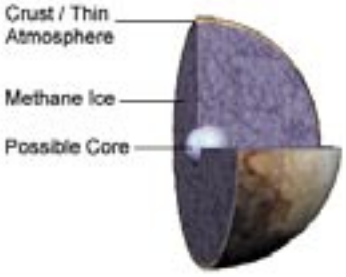
My advice to anyone interested in this occupation:

The trick is finding what you want to do. Once that happens, the sky is the limit! Find a way to keep yourself scientifically connected with others in your field. Don't spend too much time alone in a lab or on a computer.

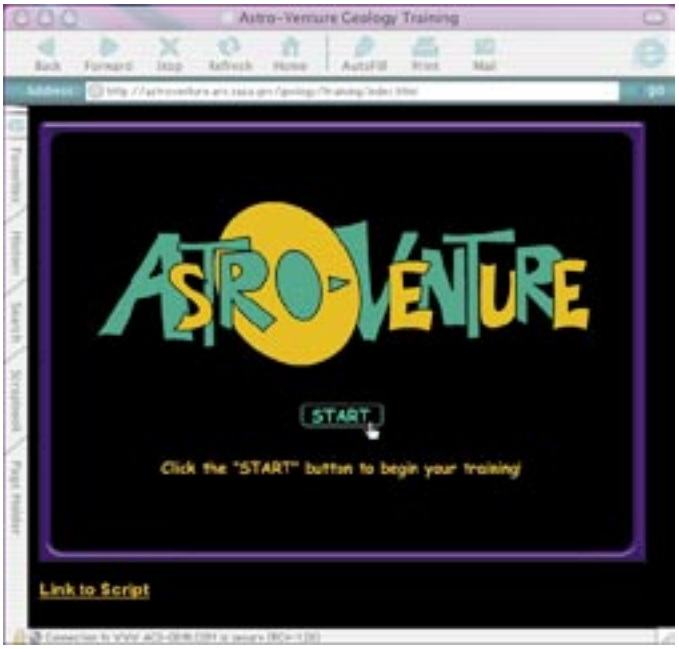
Planetary Geology Comparison Chart

Planet	Magnetic Field	Crust Movement	Mantle Movement	Image of the interior
Mercury	Yes	Ancient evidence, before the planet cooled. No current movement	Ancient, before the planet cooled. No current movement	
Venus	No	Possibly	Possibly	
Earth	Yes	Yes	Yes	
Moon	No	Ancient evidence, before the moon cooled. No current movement	Ancient, before the moon cooled. No current movement	
Mars	Localized, not global	Ancient evidence, before the planet cooled. Probably no current movement	Ancient, before the planet cooled. Probably no significant current movement	

Planetary Geology Comparison Chart

Planet	Magnetic Field	Crust Movement	Mantle Movement	Image of the interior
Jupiter	Yes	No crust	N/A	
Saturn	Yes	No crust	N/A	
Uranus	Yes	No crust	N/A	
Neptune	Yes	No crust	N/A	
Pluto	No	Unknown, most likely no current movement	Most likely no	

Geology Training Module Screen Shots



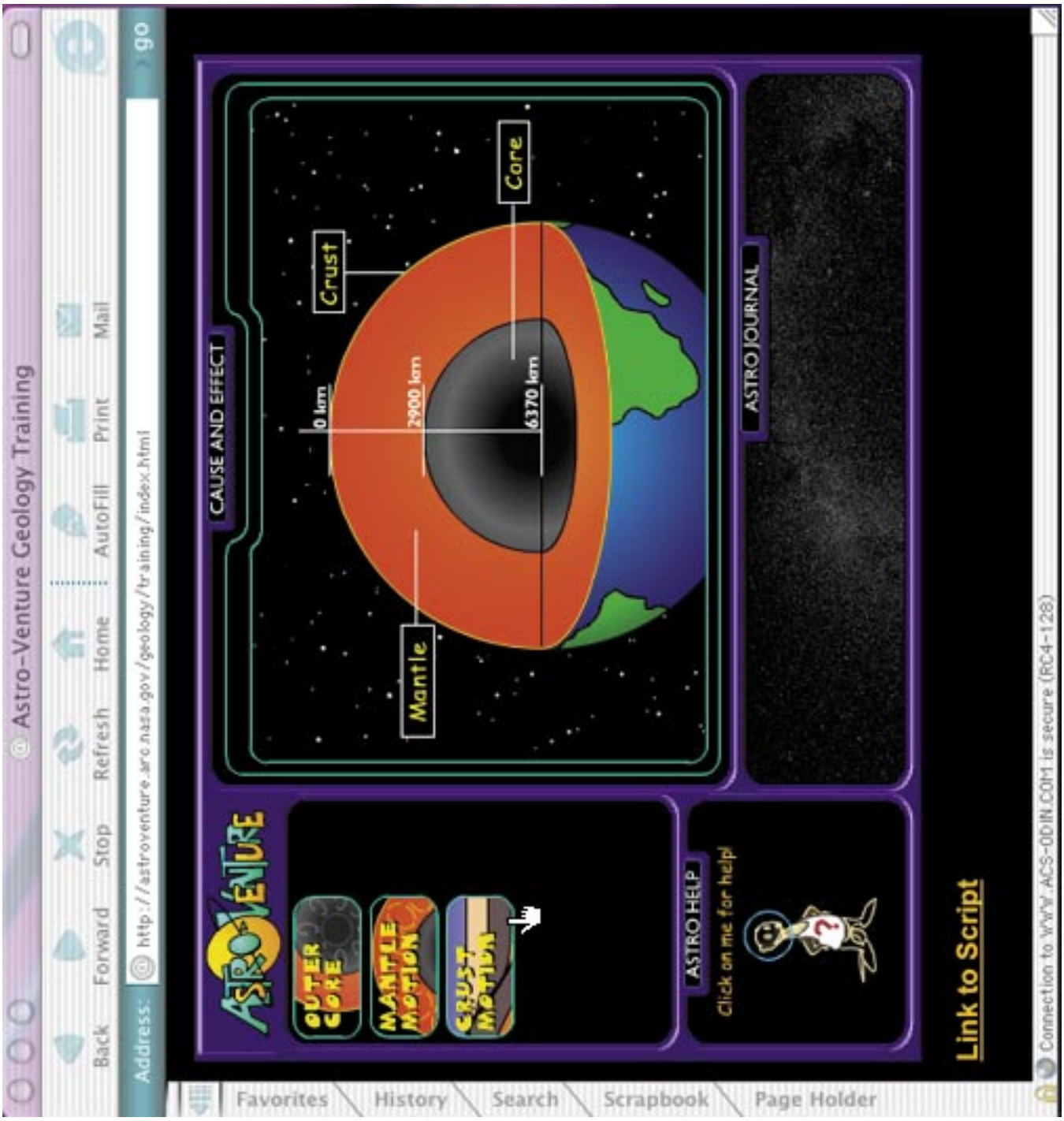
1. Press start to begin Training Module.

2. Astro Ferret introduction featuring NASA careers

3. Enter your name or your team's name.

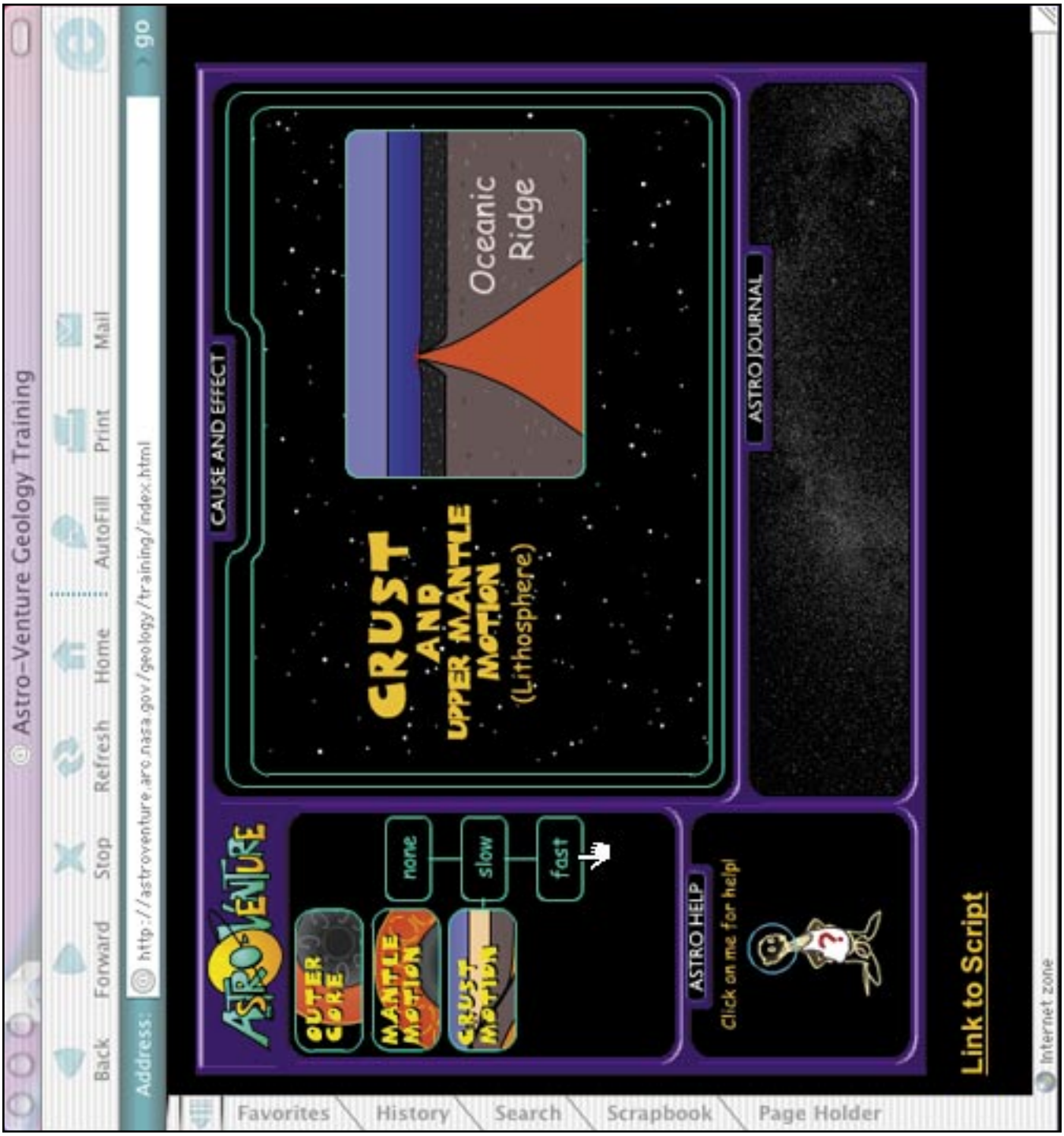
4. Astro Ferret introduces the Geology module.

Geology Training Module Screen Shots



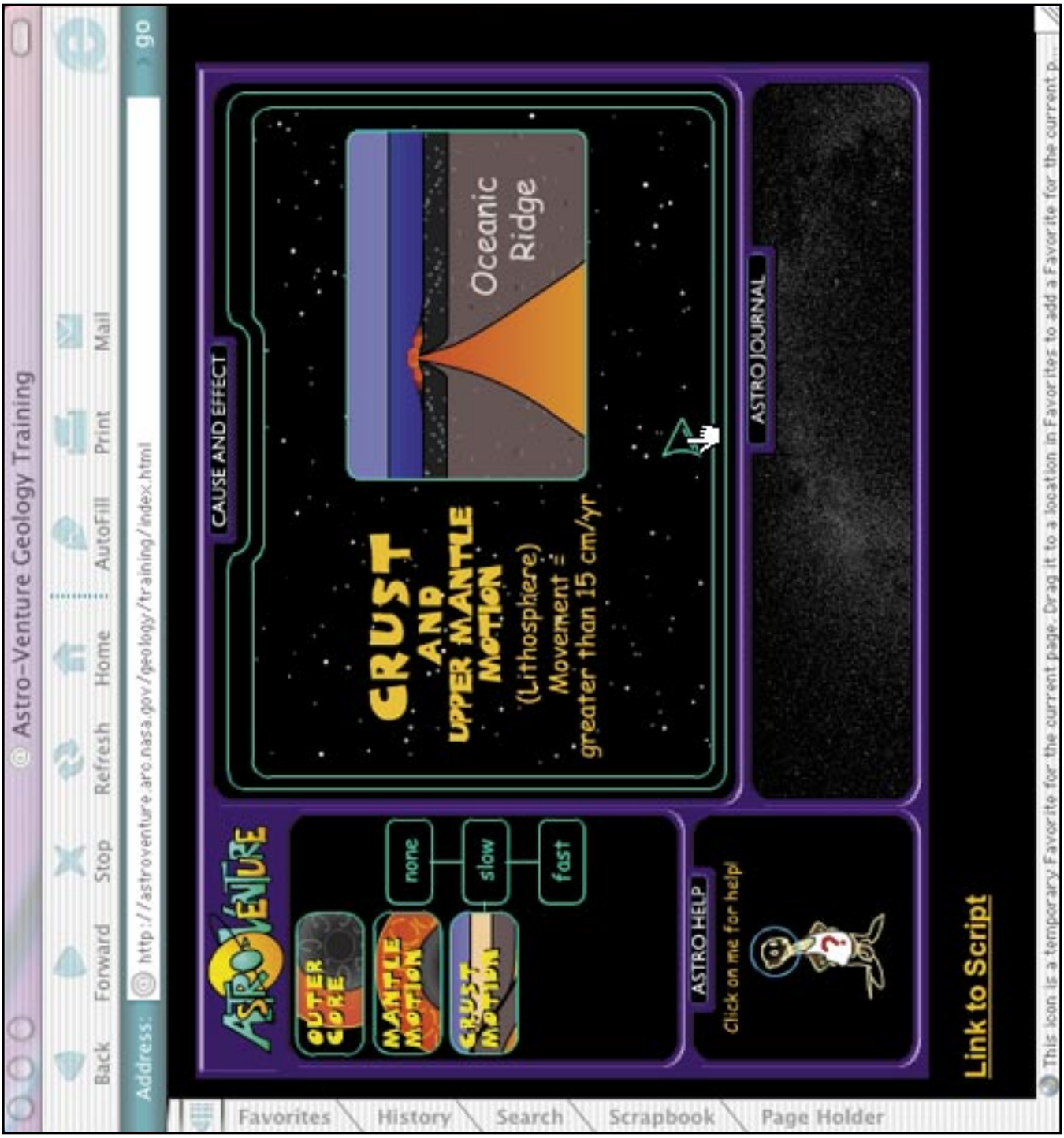
4A. Select a feature, such as "Crust Motion."

Geology Training Module Screen Shots



4B. Select a sub-menu button, such as "fast."

Geology Training Module Screen Shots

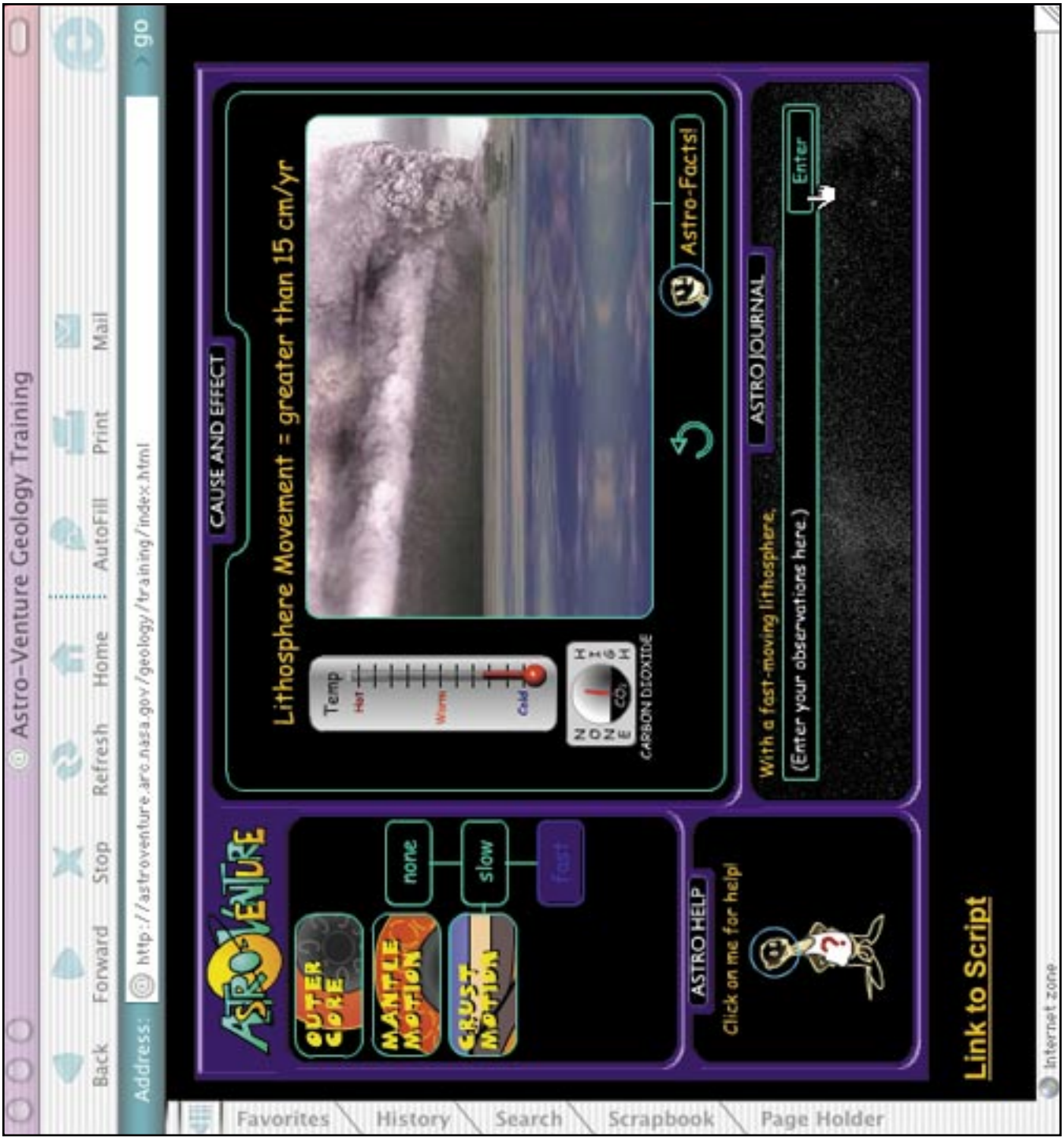


4C. Click on "Play" to see the effect on Earth.

Geology Training Module Screen Shots

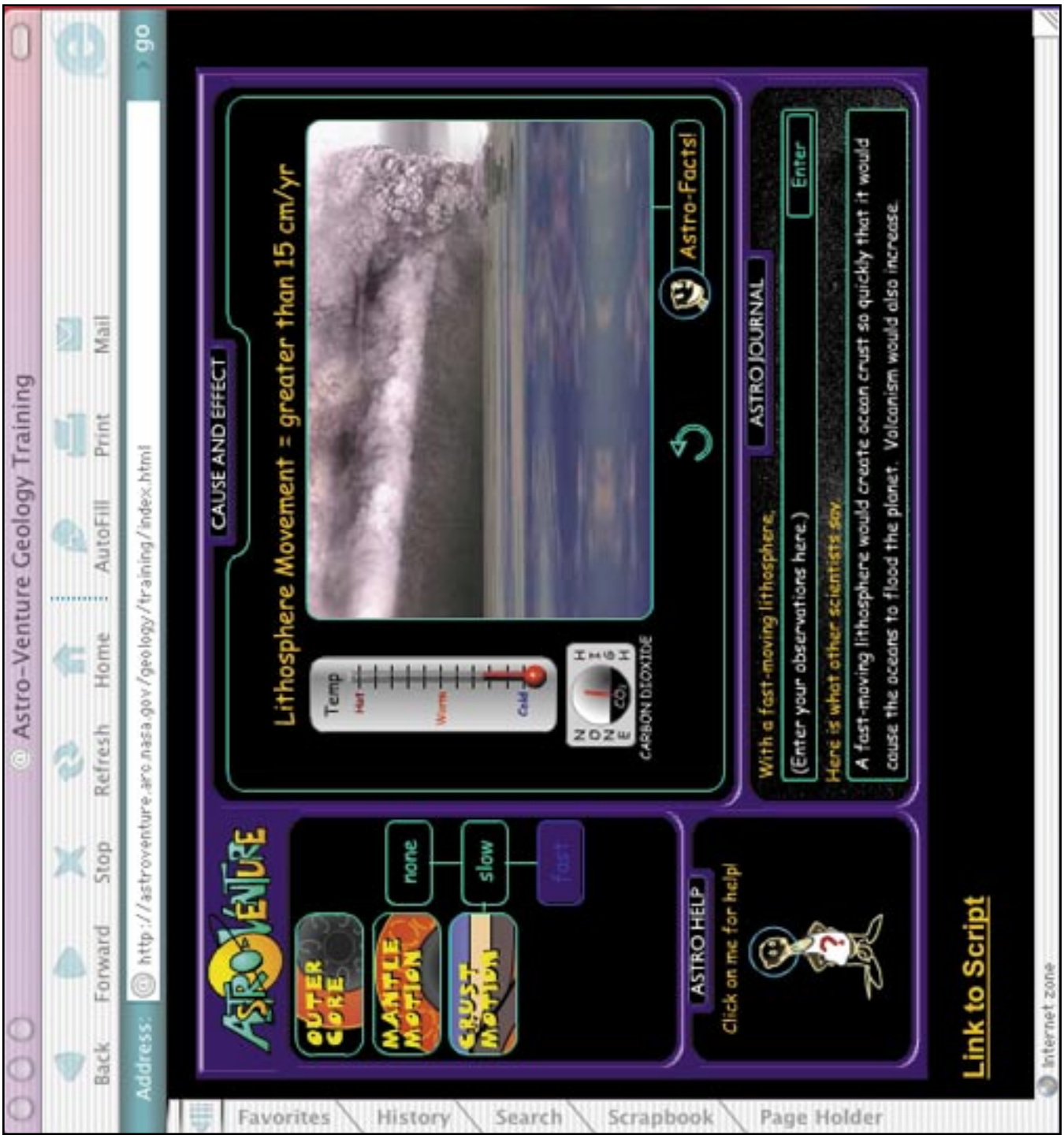
The "Replay" button can be clicked repeatedly to view animation again.

Geology Training Module Screen Shots



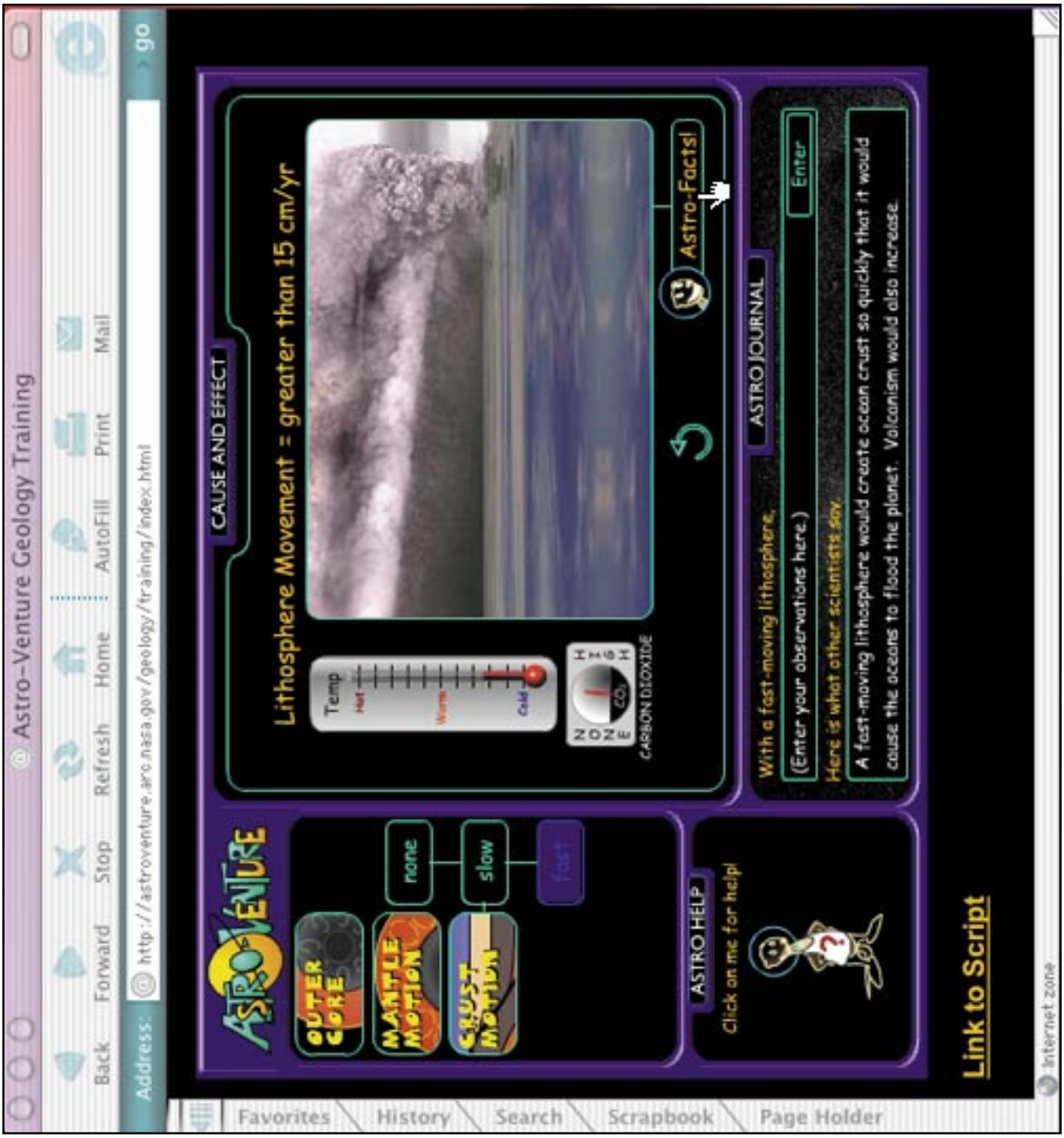
4D. Record what you observe in your Astro Journal.

Geology Training Module Screen Shots



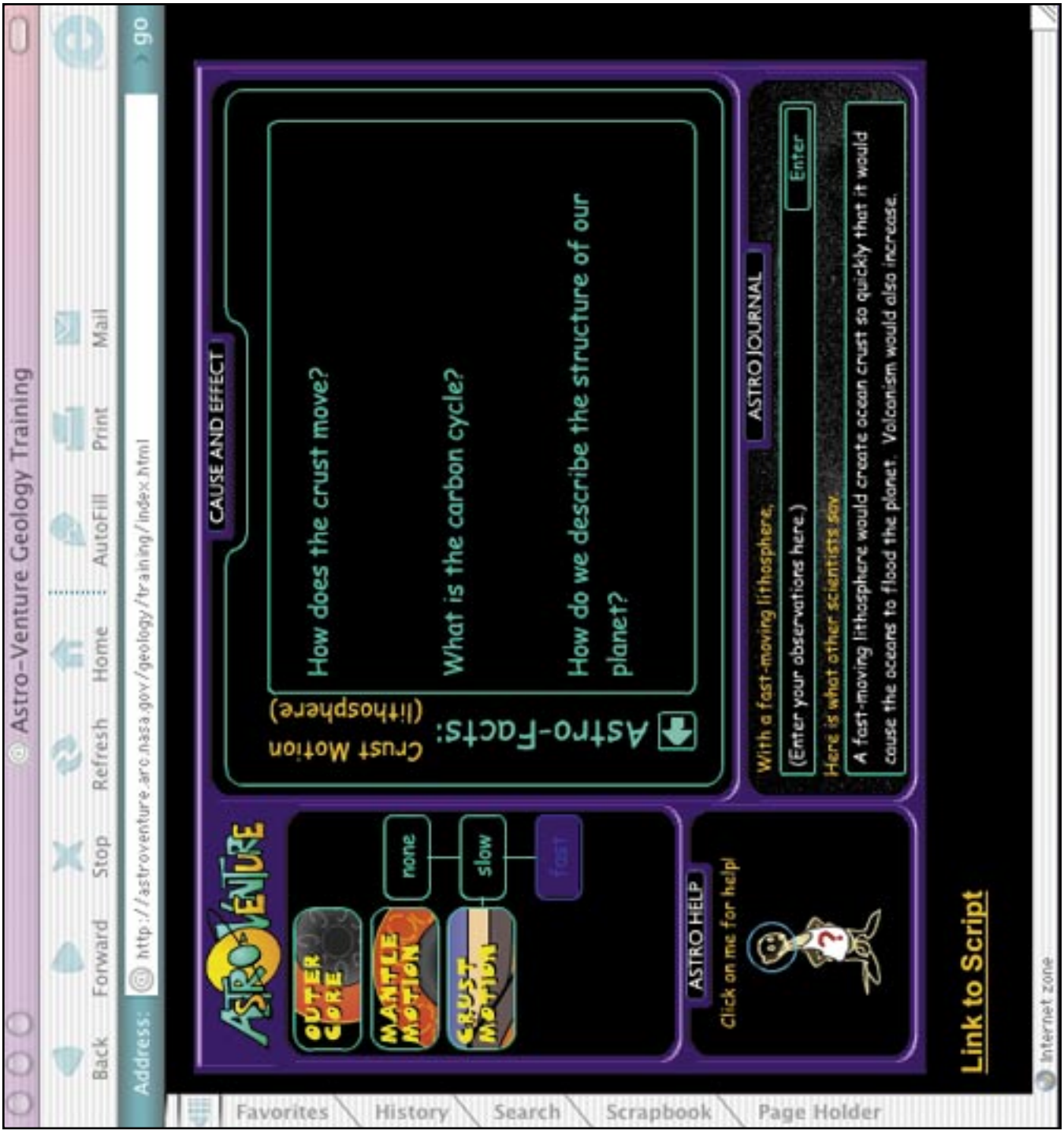
4E. Be sure to read the Scientist's feedback.

Geology Training Module Screen Shots



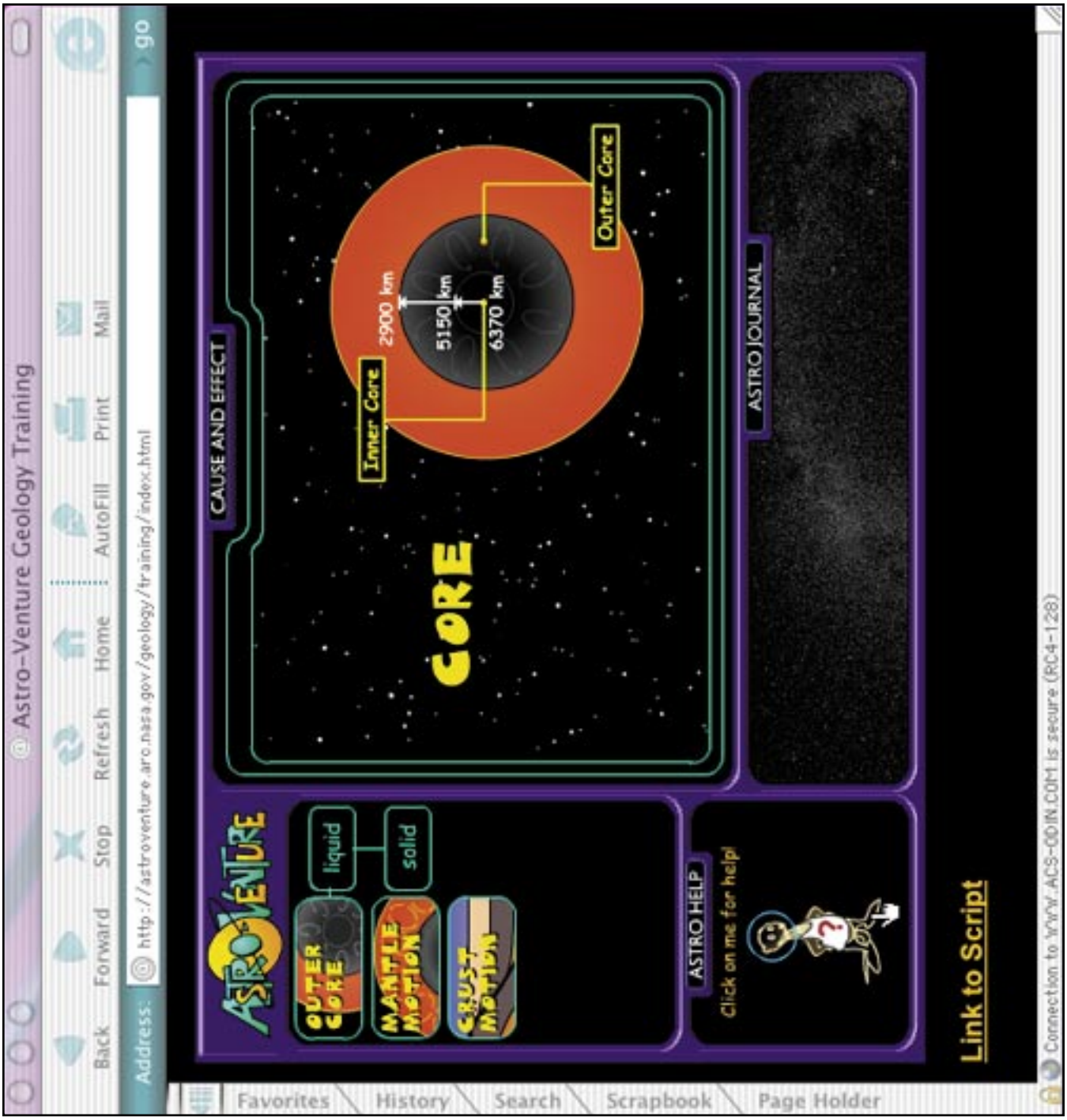
4F. Click on the Astro Facts button for background information and a glossary.

Geology Training Module Screen Shots



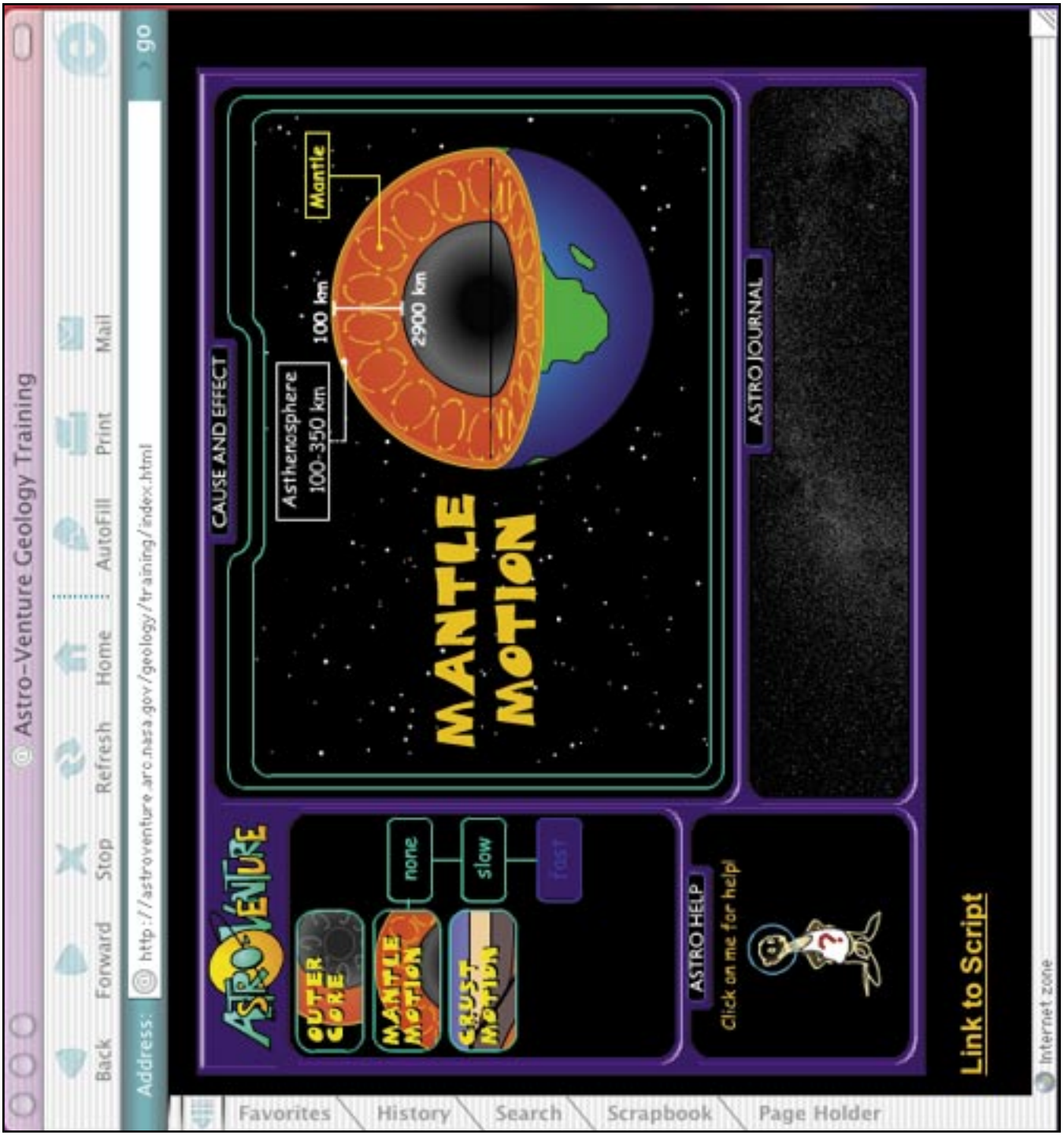
4G. Read about Astro-Facts related to the subject.

Geology Training Module Screen Shots



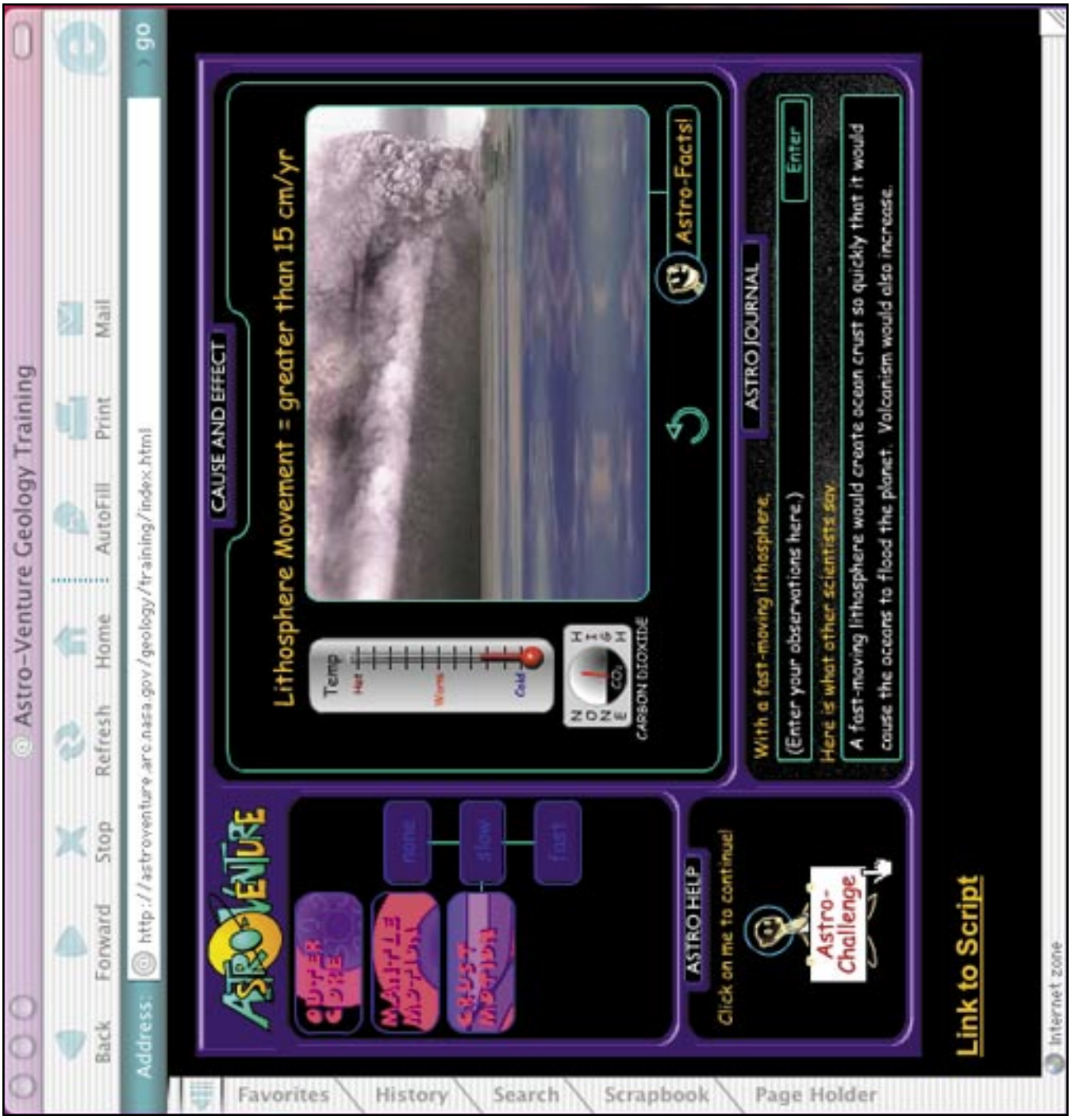
4H. Click on Astro Ferret if you need help navigating through the module.

Geology Training Module Screen Shots



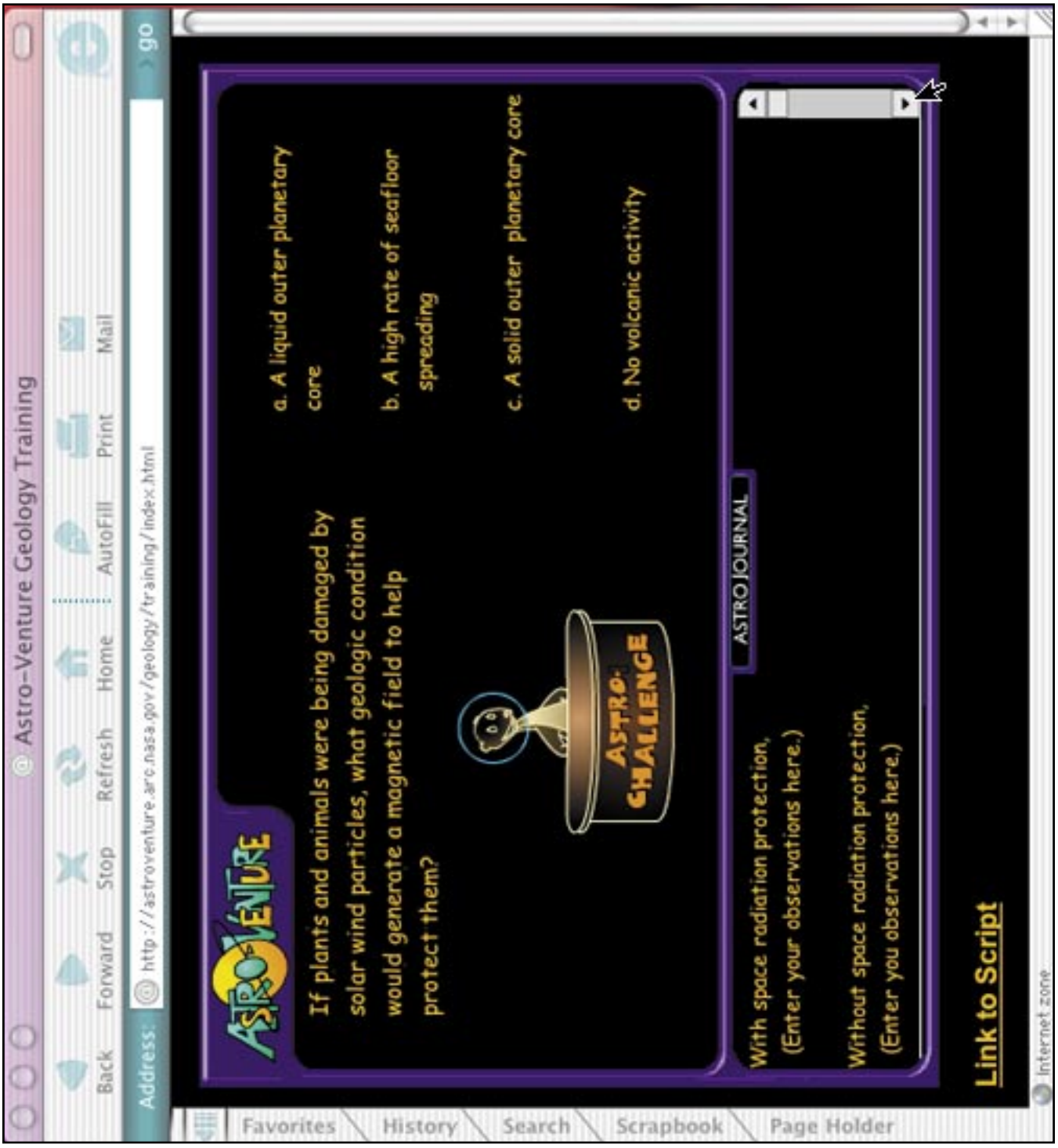
4I. Continue using steps 4A-4H for all other features and sub-menus, and record your observations. (Buttons will turn purple once you have completed the section.)

Geology Training Module Screen Shots



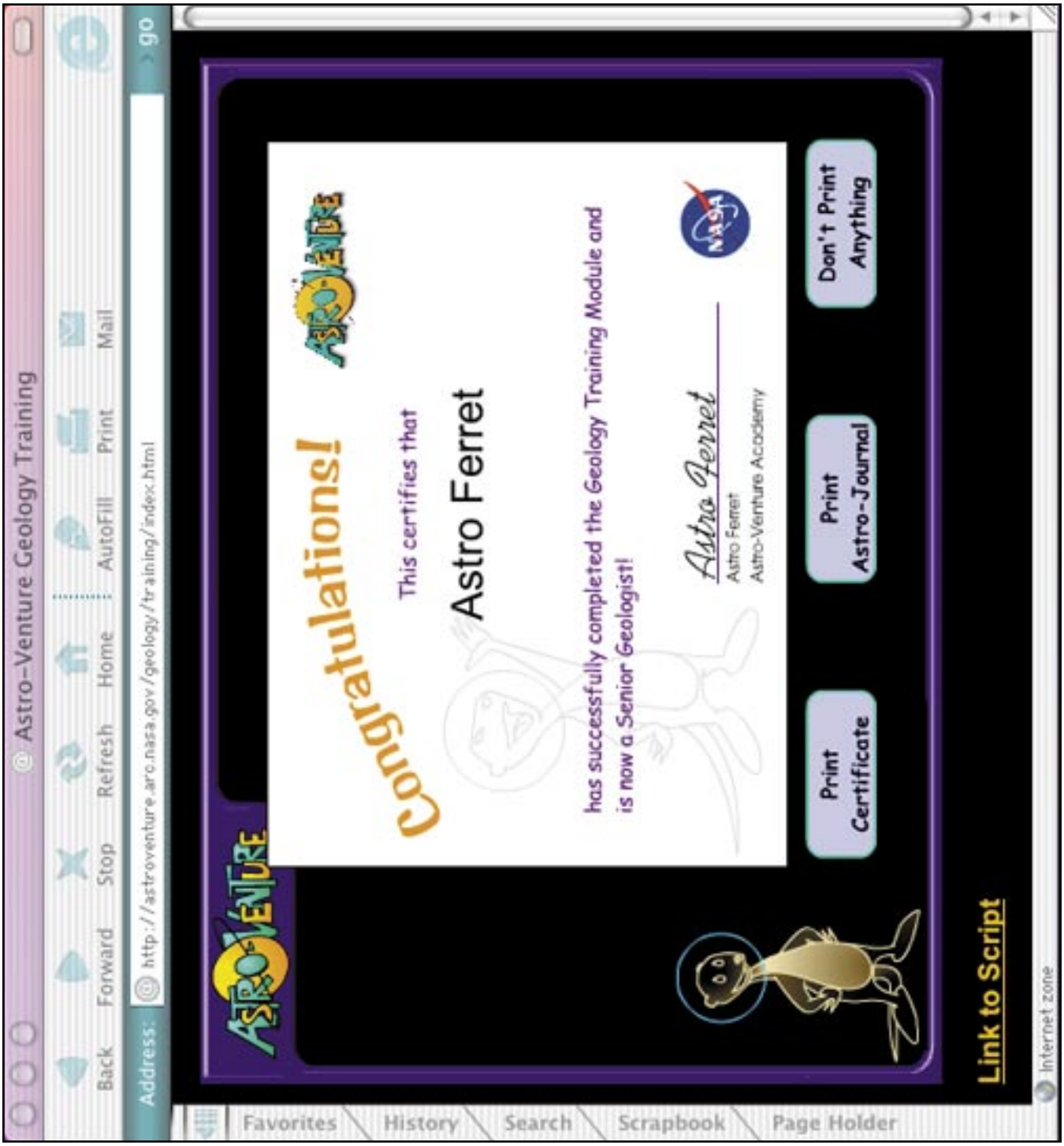
5. When you have completed all of your observations, Astro Ferret will appear with the Astro Challenge button. Click the button to begin your Astro Challenge.

Geology Training Module Screen Shots



6. Be sure to use your notes in your Astro Journal to help you with the Astro Challenge.

Geology Training Module Screen Shots



7. You can print your certificate and Astro Journal.

Human Survival Transparency

Humans need:	Reason:	What Factors Provide This:
Food	Gives us energy so that we can move, grow, and function. It also gives us nutrients to build and mend bones, teeth, nails, skin, hair, flesh, and organs.	
Oxygen	Helps us to obtain energy from sugars.	
Water	Allows nutrients to circulate through the body, allows the body to filter out waste and poisons and helps to regulate body temperature.	
Moderate temperature (Average global temperature below 50º C)	Allows us to maintain an average body temperature of 98.6° F/37°C and to maintain water in a liquid state at all times.	
Protection from poisonous gases and high levels of radiation	To prevent cancer, disease and damage to the body.	
Gravity	Allows our biological systems to develop and function normally.	

Geologic Conditions Transparency

Predicted Geologic Condition	Observed Geologic Condition	Reason